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REHABILITATION OF EXISTING OUTSIDE PLANT

CONTENTS

1. GENERAL

1.01 This section is intended to provide REA borrowers, consulting engineers, contractors and other interested parties with technical information for use in the design and construction of REA borrowers' telephone systems. It discusses in particular the problems involved in retention and rehabilitation of existing outside plant.

1.02 This section replaces REA TE & CM-215, Issue No. 1, dated April 1955. The section is reissued to provide minimum ground line circumferences of poles in charts of a type covering the following conditions: (1) span lengths to 700 feet; (2) number of wires in steps of two; and (3) margins of strength (factors of safety) of 1.0 and 1.33 in separate charts. It also includes data for aerial distribution wire and additional information useful in evaluating the effects of corrosion on the strength of supporting strand.

1.03 Prior to any detailed consideration of the problem of retention, the general features of the most economical system design should be determined as discussed in REA TE & CM-205, "Preparation of Basic System Plan Report." After this determination, the outside plant requirements along certain routes will be known. Then the adequacy and economy of existing plant to fit in with the system plan can be considered in detail.

1.04 The problem of determining adequacy of existing plant may be divided into two parts. The first part concerns the decision as to whether or not a particular part of the outside plant is such that it can be economically retained in plant for a period of at least five years. The second part concerns the work required to put the plant in shape for economical retention for a period of at least five years. Both parts of the problem are discussed in the following paragraphs.

1.05 The tests and inspections mentioned in the following paragraphs are given as general information. It is not expected that the engineer often will find it necessary to resort to these tests but they are given for use when necessary. By this means the engineering expense will be minimized.

2. CRITERIA IN RETENTION OF EXISTING PLANT

2.01 REA TE & CM-205 gives criteria in retention and rehabilitation of plant indicating that: (1) in the design of systems such portions of the plant as are capable of expansion and/or modification should be retained if this can be done more economically than it can be replaced by new plant; (2) the period of retained life for such considerations shall be a minimum of five years; and (3) a comparison of the cost of retaining and rehabilitating or modifying existing plant to the cost of replacement with new plant shall be made on the annual charge basis over the period considered.

2.02 Where the outside plant of an existing system is in fair condition, a portion of it will frequently be usable, on an economical basis, in the new system. Some parts in sound physical condition may require replacement because of the increased number of circuits involved in the new system. This will be particularly true near the central office.

Poles may be found to have inadequate strength or height to carry the additional circuits required and cables may have an inadequate number of pairs for the new requirements. Cable frequently may be reinforced in place by paralleling it with a new cable or with aerial distribution wire. Poles, cable and wire if in good condition may be removed and reused elsewhere in the system in plant extensions after replacing plant is in service.

2.03 REA recommends a margin of strength of 1.0 initially for subscriber pole lines carrying up to five pairs of wires, either open wire or aerial distribution wire, and a margin of strength of 1.33 for more important lines which are: (1) all pole lines carrying toll or trunk circuits including those carrying one or more multichannel carrier trunk systems; (2) all subscriber pole lines carrying more than five pairs of open wires or aerial distribution wires; (3) all pole lines carrying one or more multichannel carrier systems regardless of the number of wires; and (4) all pole lines supporting sheathed cable on suspension strand. These margins should be used in determining whether or not the poles are suitable for retention.

3. FIELD SURVEY OF EXISTING PLANT

3.01 A field survey by the engineer is necessary to determine whether any portions of the existing outside plant are worth retention. The survey with the exercise of good judgment should enable the engineer to quickly determine what parts of an existing system should be considered for retention. Portions of plant that obviously are of no value in the proposed system can be eliminated from further study. REA TE & CM-205 outlines the steps necessary in making such a field survey of existing outside plant. If any plant is determined by the survey to be suitable for retention, the detailed inspections required are outlined in the following paragraphs. The records to be made on inspection are mentioned therein.

4. CONSIDERATIONS IN RETENTION OF OPEN WIRE

4.01 In considering whether or not existing open wire lines should be retained, the following should be observed: (1) condition of the wires, poles, crossarms, brackets, braces, guys and anchors; (2) span lengths, clearances and sag conditions; (3) necessity for tree and brush trimming; (4) availability of space for the additional wires required, and (5) the type of transposition systems used. In many situations a representative section of open wire line will furnish satisfactory conclusions on which to base a decision.

4.02 Iron or steel line wire may require inspection at intervals of one or two miles or where changes in time of installation are noted. The wire still having a complete coating of zinc can be retained. However, if the galvanized coating has disappeared in such quantity that rust spots are visible the wire should be considered as unsatisfactory since it has short remaining life. Service life of galvanized steel wire is largely influenced by the time it takes the galvanizing to disappear from it. Three different classes of zinc coating have been used on steel and iron line wire. Class A is the lightest coating and is the coating ordinarily found on wire erected in past years. The zinc life is dependent on the atmospheric conditions where the wire is erected, and for the commonly-used Class A zinc-coated steel or iron wire, it varies from a period that can be measured in months in corrosive atmospheres to many years in arid rural regions.

4.03 The number of splices in the wire should be observed as well as the sag of the wires and sag difference between wires. Too many splices or excessive sag differences requiring extensive resagging, together with other defects such as badly rotted poles, unsuitable transpositions, et cetera, in the line may be sufficient cause for abandonment of a line. Sag differences between wires tend to cause crosstalk and mid-span hits. Sag tables should be consulted to determine whether or not the wire sags are reasonably close to the required values. Too much sag, in addition to lessening ground clearance, will permit more mid-span hits between wires than when the wires are properly sagged. Too little sag, with the resultant increased tension tends to increase wire vibration with resultant possibility of fatigue failure due to wind blowing across the line, but the application of vibration dampers will minimize this problem. Mid-span hits are functions of span length, sag, sag equality, wire spacing and wind velocity. Increases in wind velocity or span length tend to increase the probability of hits. Reducing wire spacing increases the probability of hits.

4.04 The transposition system used on the existing line may not conform to the transposition requirements of the new system. If additional circuits are to be strung on the line, retransposing may be required in the existing plant to coordinate the original and the new circuits. This may require untying the wires and throwing in new transpositions which is an expensive operation. In conjunction with other defects noted in a line, this may make replacement of the wire more economical than retention.

5. CONSIDERATIONS IN RETENTION OF POLES

5.01 The pole inspection outlined below is for poles not jointly used for power and telephone circuits. Detailed inspection of jointly used poles, if indicated as needed, should be arranged for with the owner of the poles. See REA TE & CM-690, "Joint Use of Poles."

5.02 One objective in the inspection of poles is to determine whether or not they have sufficient strength at the ground line to support the additional facilities required by the Basic System Plan Report. Lines that carry cable or open wire lines with three or more circuits require closer inspection than lines carrying a single circuit. A line having many poles that have inadequate strength ordinarily is not worth rehabilitation.

5.03 Pole lines considered for retention also should be observed for decay above ground, splintered tops, splits, checks, woodpecker holes, ant and termite infestation, and burning. If many poles are in bad condition from such causes, the line should not be retained. Spot checks of poles can be made by pushing on them with pike poles or by a similar method to determine whether they are badly decayed below the ground line. Pike pole tests should only be made with the owner's consent because of possible pole breakage and the hazard created thereby. All highway and railroad crossing poles should be examined. Treatment or lack of treatment with preservatives will affect the need for detailed inspection. Poles that appear to be sound at the ground line and are otherwise in fair condition can be considered for retention if added service will not increase the number of circuits to a point where larger size poles will be required.

5.04 Under ordinary conditions no treated pole in place for less than ten years should need ground line inspection or sounding tests.

5.05 Poles covered by the above paragraphs must have enough sound wood at the ground line to have sufficient strength for the predicted number of circuits to withstand transverse loads of wind on ice covered wires and cables for the storm loading district where the line exists specified by the National Electrical Safety Code (NESC). Minimum required circumferences at the ground line are functions of the span length, pole height, wire load, loading district involved and species of timber. Charts 1 to 6 are provided herewith giving the required minimum ground line circumferences.

5.06 Sufficient care should be exercised in examining an existing line to determine whether or not all of the poles in the line are in the same relative condition. In those cases where all the poles in the line are in the same relative condition and span lengths are reasonably uniform, it is not necessary to make ground-line inspections on all poles in the line; about every twentieth pole should be examined at the ground line and the circumference checked against the appropriate chart of minimum circumferences.

5.07 Situations may be encountered where lines which have been in existence for many years may have had pole replacements to such an extent that the date the line was built has little bearing on the decision as to whether or not to retain it. If about 1/3 or more of the poles are relatively new (say not over five years old) and the remainder are in fair condition, the line may merit retention. Old pole lines usually have a considerably greater number of poles per mile than a new line built according to REA recommendations. The number of poles required to put an old style short span line in satisfactory condition may be nearly enough to build a new line, in which case the old line should be considered for abandonment.

5.08 If the pole class is known for treated poles in good condition, ground-line circumference data are not required and the adequacy can be based on data in REA TE & CM-611, "Design of Pole Lines."

6. MINIMUM GROUND-LINE CIRCUMFERENCES OF POLES

6.01 Facilities other than bare wire on a pole line, such as insulated wire, aerial distribution wire, strand and cable, can be equated in terms of bare wire in accordance with Table 1. This is for use in determining the ability of a pole to withstand the transverse load created by wind pressure on the conductors in the presence of storm load.

Table 1

APPROXIMATE EQUIVALENTS OF POLE ATTACHMENTS IN NUMBERS OF .109 INCH DIAMETER BARE WIRES

Attachments	Storm Loading Districts Heavy	Medium	Light
1 bare wire of diameter other than .109 inch	1	1	1
1 and 2 pair aerial distribution wire, all gauges	2	2	4
4 and 6 pair aerial distribution wire, 19 gauge	2	2	6
12 and 18 pair aerial distribution wire, all gauges	2	2	8
11 pair aerial distribution wire, 22 gauge	2	2	8
16 pair distribution wire, 22 gauge	2	2	8
Cable on 5/16 inch (6M) strand	4	6	16
Cable on 3/8 inch (10M) strand	6	6	22

6.02 Charts 1 to 3 indicate the minimum ground-line circumference of sound wood of poles for various species of timber, numbers of equivalent wires, pole heights and storm loading districts at a margin of strength of 1.0 and Charts 4 to 6 give this information for a margin of strength of 1.33. Decayed wood should be removed before the pole circumference is measured. The use of the charts is explained on a page facing Chart 1.

6.03 Poles supporting wires over railroad tracks must comply with the requirements stated in REA TE & CM-617, "Railroad Crossing Specifications." It specifies that poles shall be replaced when they have deteriorated to two-thirds of their required initial strength. REA TE & CM-617 includes a table which gives the minimum ground-line circumferences of various classes, species, and lengths for poles which have deteriorated to two-thirds of their initial strength.

7. CONSIDERATIONS IN RETENTION OF CABLE

7.01 Lead-sheath cable frequently may be considered for retention. The first consideration is that its number of pairs should be sufficient to meet the requirements for the initial period (five years). If cost studies made as described in REA TE & CM-218, "Plant Annual Cost Data for System Design Purposes," show that the charges will be sufficiently less by replacing a cable with a larger size rather than reinforcing with a paralleling cable, there will be no need to examine the condition of the cable. The presence of all conductors under one sheath results in better distribution and greater flexibility and, in general, is preferable to two parallel cables. (See REA TE & CM-629, "Cable Plant Layout.")

7.02 In addition to having a sufficient number of pairs, lead-sheath cable to be retained in plant should have a sheath in reasonably good condition and a recent trouble record which indicates that it will not be a source of excessive maintenance expense. If records show that aerial lead-sheath cable is developing more than one sheath trouble per mile of sheath per year, it is in questionable condition for retention. Numerous trouble splices are an indication of cable in poor condition. Underground lead-cheath cable to be retained should not show a trouble record of more than about one sheath trouble for five miles of sheath per year.

7.03 Suspension strand should be inspected for corrosion, which can be expected to be most serious in hot humid climates, coastal areas, around chemical plants, railroad yards, railroad crossings

or other places where corrosive atmospheres exist. If the entire length of strand is badly corroded, it should be replaced. The strand should be closely examined at deadend eyebolts where the strands tend to open up, permitting corrosion. Uncorroded strand can be expected to last another five years except possibly where a newly established manufacturing or chemical plant may cause rapid corrosion.

7.04 Experience shows that strand takes longer to lose its galvanizing and lasts longer than bare conductors after the galvanizing has disappeared. The expected life of strand after losing its zinc surface, as with single conductors, will depend on the local atmospheric conditions. Strand life can be measured in months in contaminated atmospheres and in years in arid rural regions. As with wire, consultation with neighboring utility companies will be of considerable benefit in determining life expectancy of strand.

7.05 Where strand is corroded but appears to have adequate life, it is desirable to measure the diameter of the strand with a micrometer after cleaning the strand with emery cloth down to bright metal. Inspection and measurements probably will be required at railroad corssings, around chemical plants and where the strand has been enclosed by tree guards. The minimum diameters of 6M and 10M strand permissible for rehabilitation are given as a function of tension in Table 2. Strand with less diameter than given in this table is unsafe and should be replaced. This test should be made at a pole. The test point should be painted after the test, using a metal paint such as zinc gray paint or asphaltic paint.

TABLE 2

Minimum diameter of good steel in corroded utilities grade galvanized steel strand for spans of 150 feet or less.

Strand Tension - Lbs.	Minimum Diameter of Strand Inches 6M	10M
500	.240	
750	.240	
1000	.256	
1250	.263	
1500	.270	
1750	.277	
2000	.284	.256
2250	.291	.256
2500	.301	.256
2750	.308	.256
3000	.314	.261
3250	.320	.268
3500	.325	.273
3750		.277
4000		.281
4250		.287
4500		.291
4750		.295
5000		.300

NOTE: For spans averaging over 150 feet in length add .015 inch to the diameters indicated above.

7.06 Data for use in determining the tension in a suspension strand supporting lead sheath cable are given in Table 3, "Weight of Cable" per foot, and Tables 4, 5, and 6, "Lead Sheath Cable Sag and Related Tension." In applying this information it will be necessary to do some approximating. The cable size may not be exactly 0.5, 1.0, 1.5, et cetera, pounds per foot, in which case the nearest half pound value should be used. The sag and tension data are given for the "final" condition as may be found after storm loading. The following example indicates how to use these data. Assume a 26 pair, 22 gauge lead sheath cable on 6M strand has 175 foot spans, the temperature is 70 degrees and the location is in the heavy loading district. From Table 3 the cable can be considered as 0.5 pound per foot. The cable sag should be measured. Assume it proves to be about 28 inches. The sag data of Table 4 shows this sag falls at the point marked "X" on the table. The related tension data shows it to be not over 1250 pounds, which should be the value used in Table 2. Table 2 indicates that the minimum permissible diameter would be 0.263 inches.

7.07 Lead-sheath cable suspended from strand in galvanized cable rings should be inspected for cracks and ring cuts in the sheath. Cracks will be found more often at splices than elsewhere in the sheath. At the same time the cable may be examined for evidence of crystallization and corrosion. Bowing of cable suspended in rings is a general condition and is conducive to crystallization of sheath and sheath breaks. One method for correction of bowing is by pulling slack in the cable but this is expensive. The amount of work required on existing cable should be considered. A ring supported cable may be badly bowed, have serious ring cuts, its terminals may have excessive broken lugs, its terminals may be too small or terminal counts may require changing, and loading coils may be needed. These factors add substantially to the cost of splicing and repair work which may justify abandonment.

7.08 Lead-sheath cable that is lashed to suspension strand probably will be newer and in better condition for retention than ring suspended cable and may need only a superficial inspection. Plastic-sheath cable that is lashed to suspension strand likewise should need only superficial inspection. The same is true for all types of cable in underground ducts. However, the trouble record of buried cable with any kind of sheath material should be examined and replacement of the cable should be considered if it has given excessive trouble from deterioration. Megger tests as outlined for cable in REA TE & CM-680, "Outside Plant Acceptance Tests," are advisable in order to

determine the condition of the cable insulation, and the cable should not be retained if insulation resistance is so low that ordinary repairs cannot clear it.

7.09 Lead-sheath cable in rings should not be reinforced by another cable attached to the existing strand by lashing the two cables together if the work of lashing will strain the sheath of the old cable and result in cracks or weak spots that will crack later. A more satisfactory method of reinforcement is by placing a new strand and lashing the new cable to it. If the existing cable and strand are relatively new, it is satisfactory to lash the old and new cables to one strand provided the strand has the required strength to support both cables.

8. SUMMARY OF CONSIDERATIONS IN RETENTION OF EXISTING PLANT

8.01 Abandonment of open wire plant should be considered (1) if an excessive number of poles in a line under consideration do not have adequate strength to meet the requirements of the five year period; (2) if the line location or route is unsatisfactory due to extensive tree or brush growth or lack of satisfactory ground clearance for wires; (3) if there is a lack of sufficient space to provide ground clearance for wires that are to be added; (4) if the existing wires are deteriorated to such an extent that they must be replaced; (5) if the line is not properly guyed and requires extensive additional guying; (6) if the line requires extensive retransposition; (7) if extensive resagging of wire will be necessary to match the sag of any new wires that must be erected on the same poles; or (8) if a study of the annual charges appreciably favors new plant. Any one of the above in itself may not be sufficient cause for abandonment but a combination of items may be.

8.02 Abandonment of cable should be considered (1) if the lead sheath is badly ring cut and indications are that it will give excessive trouble from this cause in the five-year period; (2) if the cable is so badly bowed that slack should be cut out; (3) if the strand is so badly corroded that it is unsafe to support two men on a platform in the middle of the span; (4) if the lead sheath shows indication of crystallization; (5) if the insulation as tested by a megger shows a general condition of low insulation; (6) if there are many trouble splices; or (7) if a study of annual charges appreciably favors new plant. As with wire, one of these causes may not be sufficient to require abandonment.but a combination of them may be.

8.03 No positive conclusion can be given as to when a cable should be reinforced or replaced by a larger one. One factor is the cost of removal which may be more than the salvage value. Another factor is that if the old cable has many terminals in the section to be paralleled or replaced, the cost of new terminals on a new cable and transfers of drops to these terminals will be a considerable expense that possibly can be avoided by placing a parallel cable. In general it is more economical to place new terminals on a new cable than to transfer old terminals to a new cable. If the new cable has plastic sheath, splicing the old lead-sheath terminal stubs into the new plastic-sheath cable is not recommended.

9. ANNUAL CHARGES

9.01 If inspection indicates the possibility of retention of a substantial portion of plant, a comparison of annual charges should be made for the plant to be retained and the plant which would be required to replace it. Therefore, it is necessary to determine the interest charges, taxes, depreciation rates, maintenance charges on both the retained plant and proposed new plant on an annual basis. The cost of any rearrangements must also be estimated. The method of computation of annual charges is discussed in REA TE & CM-218.

9.02 The plan to be adopted should be the one that shows the lower annual charge, computed by the method explained in REA TE & CM-218. If the difference is minor, the choice should be made in favor of new plant to replace the existing plant unless there are other important specific factors favoring retention.

9.03 The first cost of plant as used in the above annual charge computations includes the cost of materials delivered to the job and the labor costs with a proper loading for overhead for erecting a new plant and removing old plant.

10. REHABILITATION WORK ON OUTSIDE PLANT TO BE RETAINED

10.01 Where it has been determined from the cost studies outlined above that a section of line merits retention, this line should be reinspected and staking sheets used to show the work needed. If staking sheets are available covering the existing construction they would be most helpful. The new sheets if used can be in simple form but should include enough information to enable a construction crew to locate the places where work is scheduled and guide them in doing the desired work. The sheets should include (1) the locations of poles, wires, crossarms, guys, drop wires, et cetera, which require replacements;

(2) the locations at which additional guying is required or where existing guys need to be pulled up; (3) places where tree and brush trimming is necessary; (4) the location of sections of the line at which slack needs to be cut out, and (5) locations at which protective devices should be placed. The staking sheets should also include the information necessary to properly construct the new plant. Work of this nature is such that a small crew of men should be able to accomplish it.

Where cost studies show that an existing length of cable on a pole line can be economically retained, it should also be reinspected and staking sheets used to indicate the location and nature of work required to put it in satisfactory condition for retention. It is expected that these repairs will be of a minor nature covering such work as the following: Repairing broken lugs in terminals; trimming trees where limbs are against cable, tightening loose guys; replacing defective poles; repairing any defective ground connections from sheath to strand and from strand to ground wires, and checking some of the cable conductors with a megger for low insulation and locating and clearing the cause if low insulation is found. This is a very necessary procedure. Sections of strand containing broken wires can be reinforced by bridging the break with a new piece of strand of the same size attached at its ends by three bolt clamps or by use of a patented splice. Consideration should be given to spray testing of existing lead-sheath cable that is to be retained. This method of testing is covered in REA TOM-1356.3, "Leak Locating in Telephone Cables by Spray Test."

TABLE 3

APPROXIMATE WEIGHT - LEAD SHEATH CABLE

	22 Gauge	19 Gauge
	Pounds Per Foot	
11	0.4	0.6
16	0.5	0.7
26	0.6	0.9
51	0.9	1.5
76	1.2	2.0
101	1.5	2.5
152	2.0	
202	2.5	

Reference: REA TE & CM-630, "Design of Cable Plant"

TABLE 4
LEAD SHEATH CABLE "FINAL" SAG AND RELATED TENSION
HEAVY LOADING DISTRICT

Cable, 0.5 pound per foot on 5/16" (6M) Strand, 1100 pounds Strand Stringing Tension, 60°

Temp. Degrees F	Spans-Feet 150	200	250	300		Spans-Feet 150	200	250	300
	Sag-Inches					Strand Tension-Pounds			
30	1[illegible].9	33.4	50.3	69.7		1283	1349	1404	1456
60	22.1	36.6	53.9	73.9		1143	1231	1308	1372
90	25.0	40.0	57.8	78.0		1017	1130	1221	1300
120	27.8	43.3	61.7	82.4		913	1030	1143	1231

(In the table, an "X" stands between the 150 and 200 columns in both the sag and tension groups.)

Note: See paragraph 7.06 for significance of the use of "X" in the above data.

Cable, 1.0 pound per foot on 5/16" (6M) Strand, 1100 pounds Strand Stringing Tension, 60°

Temp. Degrees F	Spans-Feet 100	150	200	250	Spans-Feet 100	150	200	250
	Sag-Inches				Strand Tension-Pounds			
30	13.1	26.8	43.8	64.2	1430	1582	1719	1834
60	14.6	28.9	46.4	67.4	1275	1463	1620	1750
90	16.3	31.3	49.3	70.6	1143	1355	1527	1665
120	18.2	33.7	52.2	73.9	1025	1262	1443	1594

Cable, 1.5 pounds per foot on 3/8" (10M) Strand, 2100 pounds Strand Stringing Tension, 60°

Temp. Degrees F	Spans-Feet 100	200	300	400	Spans-Feet 100	200	300	400
	Sag-Inches				Strand Tension-Pounds			
30	10.7	36.8	73.7	119.8	2535	2930	3315	3630
60	11.9	39.2	77.0	123.8	2290	2755	3175	3515
90	13.2	41.8	80.6	128.2	2050	2585	3040	3400
120	14.8	44.5	84.1	132.4	1830	2430	2910	3290

le, 2.0 pounds per foot on 3/8" (10M) Strand, 2100 pounds Strand Stringing
nsion, 60°

mp. ees	Sag-Inches 100	200	300	350	Strand Tension-Pounds 100	200	300	350
0	12.8	42.7	84.1	108.7	2690	3240	3715	3920
0	14.0	45.0	87.2	112.2	2455	3075	3590	3805
0	15.4	47.4	90.5	115.6	2235	2920	3455	3690
0	17.0	50.0	93.8	119.2	2035	2775	3335	3575

able, 2.5 pounds per foot on 3/8" (10M) Strand, 2100 pounds Stringing
ension, 60°

emp. rees F	Sag-Inches 100	200	300	350	Strand Tension-Pounds 100	200	300	350
30	14.8	47.8	93.2	120.0	2850	3530	4085	4330
60	16.0	49.9	96.1	123.1	2630	3380	3965	4225
90	17.4	52.3	99.1	126.4	2430	3235	3850	4115
120	18.8	54.6	102.1	129.8	2245	3095	3730	4005

From Indiana Steel and Wire Company, Inc.

TABLE 5
LEAD SHEATH CABLE "FINAL" SAG AND RELATED TENSION
MEDIUM LOADING DISTRICT

Cable, 0.5 pound per foot on 5/16" (6M) Strand, 1100 pounds Strand Stringing Tension, 60° .

Temp. Degrees F	Spans-Feet 200	250	300	350	Spans-Feet 200	250	300	350
	Sag-Inches				Strand Tension-Pounds			
[illegible]	29.5	43.6	59.8	78.1	1525	1610	1693	1773
[illegible]	32.8	47.3	63.8	82.7	1382	1489	1582	1671
[illegible]	35.0	51.1	68.4	87.5	1257	1375	1483	1579
120	39.4	55.3	73.0	92.6	1145	1279	1391	1494

Cable, 1.0 pound per foot on 5/16" (6M) Strand, 1100 pounds Strand Stringing Tension, 60°

Temp. Degrees F	Spans-Feet 100	150	200	250	Spans-Feet 100	150	200	250
	Sag-Inches				Strand Tension-Pounds			
30	12.1	24.6	39.5	57.2	1542	1726	1902	2062
60	13.7	26.6	42.4	60.2	1372	1591	1783	1958
90	15.2	29.0	45.0	63.5	1220	1463	1672	1855
120	17.3	31.4	47.9	66.8	1089	1350	1569	1762

Cable, 1.5 pounds per foot on 3/8" (10M) Strand, 2100 pounds Strand Stringing Tension, 60° .

Temp. Degrees F	Spans-Feet 100	200	300	400	Spans-Feet 100	200	300	400
	Sag-Inches				Strand Tension-Pounds			
30	10.2	34.9	68.9	110.0	2640	3100	3545	3945
60	11.4	37.3	72.2	114.1	2375	2900	3390	3805
90	12.7	39.8	75.6	118.3	2125	2720	3235	3670
120	14.3	43.0	79.3	122.8	1895	2550	3090	3540

Cable, 2.0 pounds per foot on 3/8" (10M) Strand, 2100 pounds Strand Stringing Tension, 60^{o}

Temp. Degrees F	Spans-Feet 100	200	300	350	Spans-Feet 100	200	300	350
	Sag-Inches				Strand Tension-Pounds			
30	12.4	40.4	78.6	100.7	2785	3415	3970	4225
60	13.6	42.8	81.6	104.3	2545	3290	3830	4090
90	14.9	45.2	84.6	107.9	2325	3065	3685	3955
120	16.4	47.8	88.1	111.4	2110	2904	3550	3830

Cable, 2.5 pounds per foot on 3/8" (10M) Strand, 2100 pounds Strand Stringing Tension, 60^{o}

Temp. Degrees F	Spans-Feet 100	200	300	350	Spans-Feet 100	200	300	350
	Sag-Inches				Strand Tension-Pounds			
30	14.3	45.5	87.2	111.7	2945	3705	4360	4645
60	15.4	47.6	90.2	114.8	2720	3540	4225	4515
90	16.7	49.9	93.2	118.2	2510	3385	4090	4395
120	18.2	52.3	96.4	121.7	2315	3230	3960	4270

TABLE 6
LEAD SHEATH CABLE "FINAL" SAG AND RELATED TENSION
LIGHT LOADING DISTRICT

Cable, 0.5 pound per foot on 5/16" (6M) Strand, 1100 pounds Strand Stringing Tension, 60°

Temp. Degrees F	Spans-Feet 200	Spans-Feet 300	Spans-Feet 400	Spans-Feet 200	Spans-Feet 300	Spans-Feet 400
	Sag-Inches			Strand-Tension-Pounds		
30	27.8	56.3	91.8	1589	1770	1938
60	30.7	60.5	96.6	1434	1652	1835
90	34.1	64.8	101.8	1298	1541	1742
120	37.7	69.2	107.3	1179	1438	1656

Cable, 1.0 pound per foot on 5/16" (6M) Strand, 1100 pounds Strand Stringing Tension, 60°

Temp. Degrees F	Spans-Feet 200	Spans-Feet 300	Spans-Feet 400	Spans-Feet 200	Spans-Feet 300	Spans-Feet 400
	Sag-Inches			Strand-Tension-Pounds		
30	37.8	73.2	116.6	1963	2289	2557
60	40.4	76.8	121.0	1837	2185	2469
90	43.3	80.4	125.4	1719	2088	2379
120	46.0	84.4	130.0	1610	1992	2296

Cable, 1.[illegible] pound per foot on 5/16" (6M) Strand, 1100 pounds Strand Stringing Tension, 60°

Temp. Degrees F	Spans-Feet 100	Spans-Feet 200	Spans-Feet 300	Spans-Feet 100	Spans-Feet 200	Spans-Feet 300
	Sag-Inches			Strand-Tension-Pounds		
30	14.8	45.4	86.9	1768	2297	2714
60	16.1	47.9	90.1	1616	2181	2619
90	17.6	50.4	93.4	1476	2077	2527
120	19.3	52.9	96.6	1350	1972	2441

Cable, 1.5 pounds per foot on 3/8" (10M) Strand, 2100 pounds Strand Stringing Tension, 60°

Temp. Degrees F	Sag-Inches 300	Sag-Inches 500	Sag-Inches 700	Strand-Tension-Pounds 300	Strand-Tension-Pounds 500	Strand-Tension-Pounds 700
	Spans-Feet			Spans-Feet		
30	66.5	151.9	261.4	3630	4434	[illegible]
60	69.7	156.6	267.2	3466	4303	[illegible]
90	73.2	161.5	273.2	3305	4170	[illegible]
120	76.7	166.7	279.7	3151	4040	4740

Cable, 20 pounds per foot on 3/8" (10M) Strand, 2100 pounds Strand Stringing Tension, 60°

Temp Degrees F	Sag-Inches 300	Sag-Inches 400	Sag-Inches 500	Strand-Tension-Pounds 300	Strand-Tension-Pounds 400	Strand-Tension-Pounds 500
	Spans-Feet			Spans-Feet		
30	76.2	120.4	171.7	4061	4584	5025
60	79.2	124.1	176.0	3907	4445	4901
90	82.3	128.0	189.6	3757	4315	4762
120	85.8	132.1	185.3	3612	4182	[illegible]

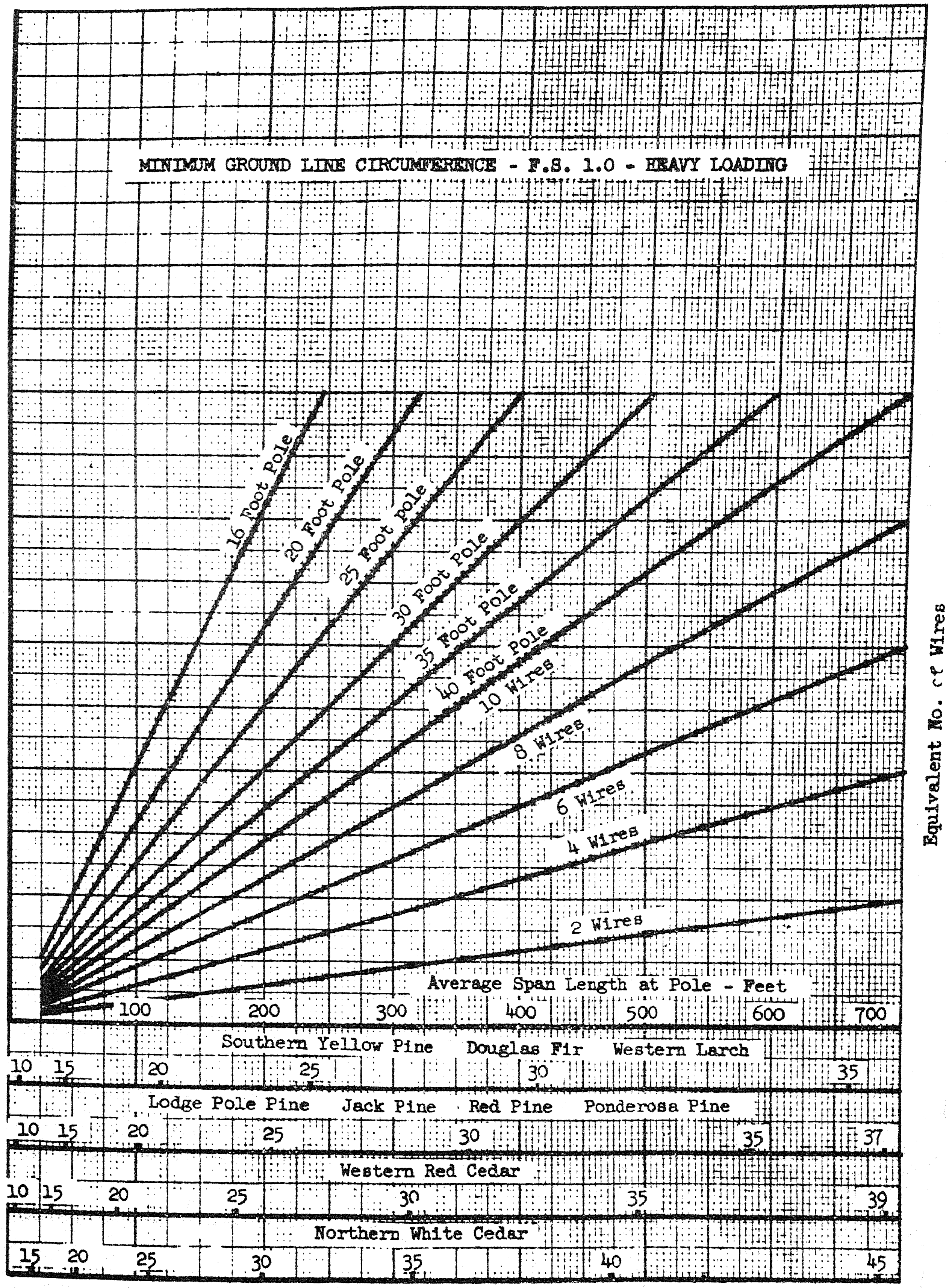
Cable, 2.5 pounds per foot on 3/8" (10M) Strand, 2100 pounds Strand Stringing Tension, 60°

Temp. Degrees F	Sag-Inches 200	Sag-Inches 300	Sag-Inches 400	Strand-Tension-Pounds 200	Strand-Tension-Pounds 300	Strand-Tension-Pounds 400
	Spans-Feet			Spans-Feet		
30	44.5	84.7	133.8	3763	4453	[illegible]
60	46.6	87.8	137.3	3594	4307	[illegible]
90	48.8	90.2	140.9	3432	4166	[illegible]
120	51.2	93.8	144.6	3274	4028	[illegible]

From Indiana Steel and Wire Company, Inc.

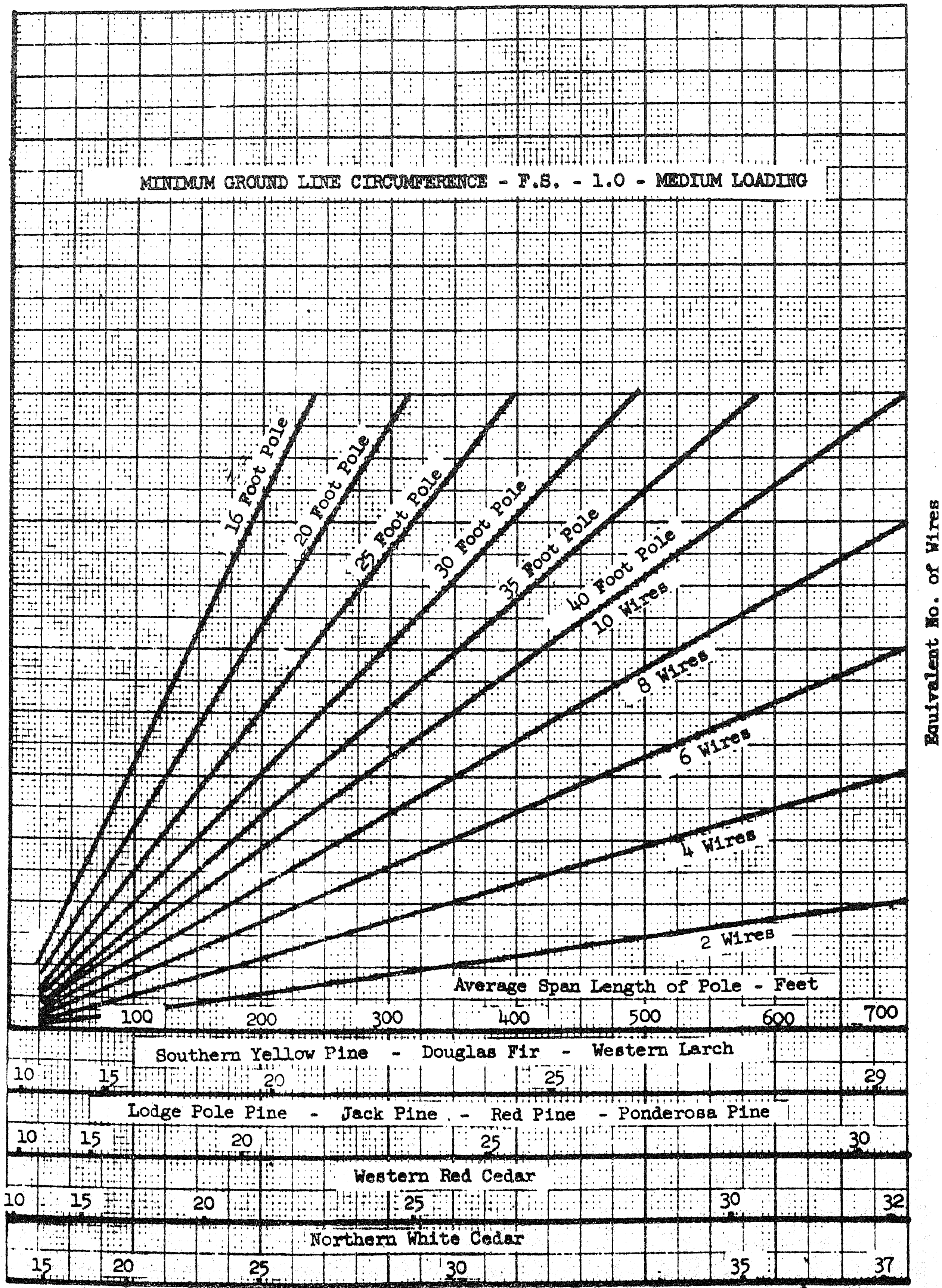
HOW TO USE CHARTS 1 TO 6

See Chart 1 which is for a margin of strength of 1.0 in the heavy storm loading district. Assume a Northern White Cedar pole is to carry 6 wires on a 25-foot pole with the two adjacent spans averaging 175 feet, in the heavy storm loading district. Locate the 175 foot point along the bottom of the chart. Trace vertically from this point to the "6 wire" diagonal line. Then trace horizontally to the "25-foot pole" diagonal line. Trace downward from this point to the "Ground Line Circumference" data for Northern White Cedar at the bottom of the chart where it will be seen that the dimension should exceed 22 inches.



Ground Line Circumference - Inches

CHART 2



Ground Line Circumference - Inches

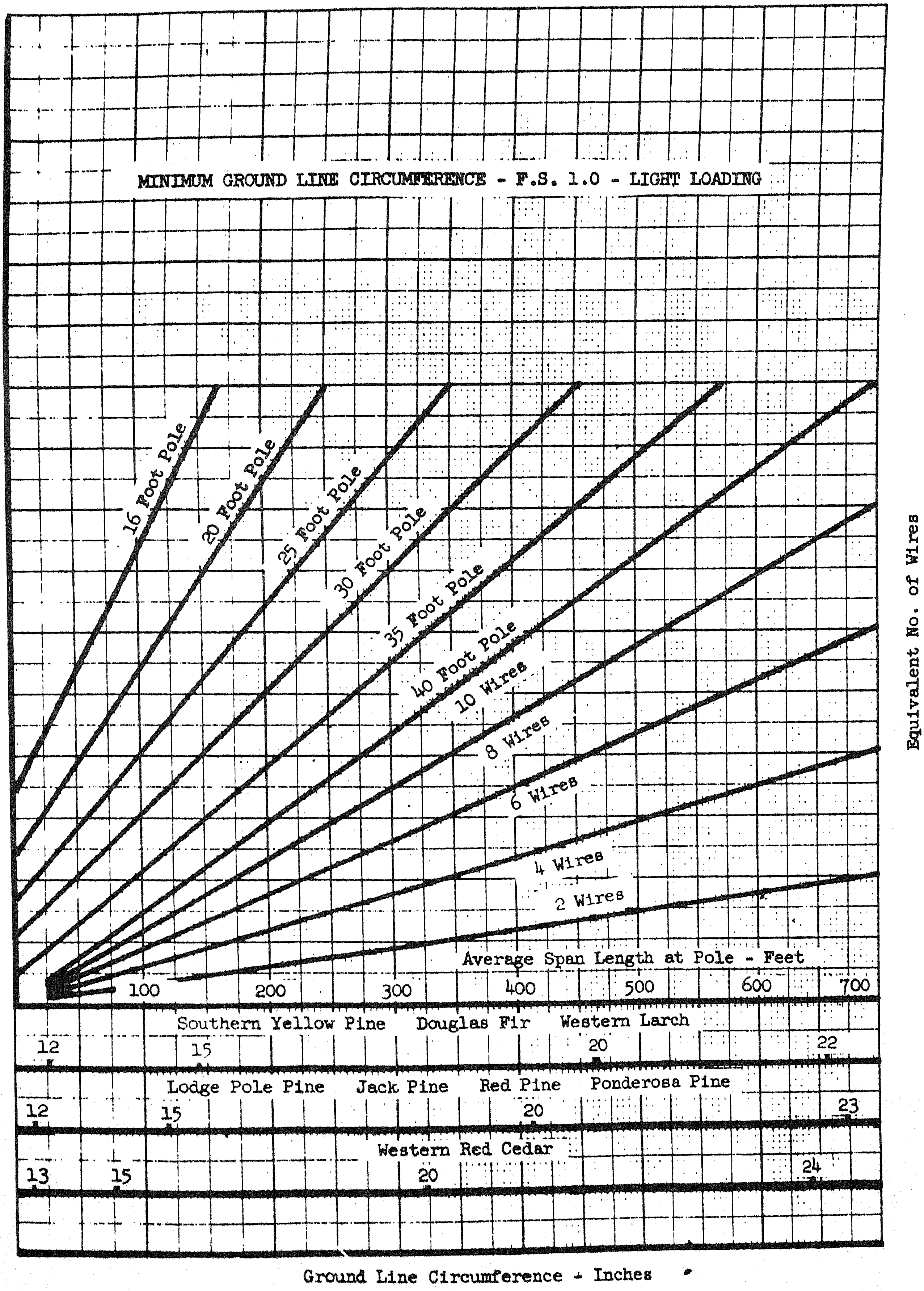
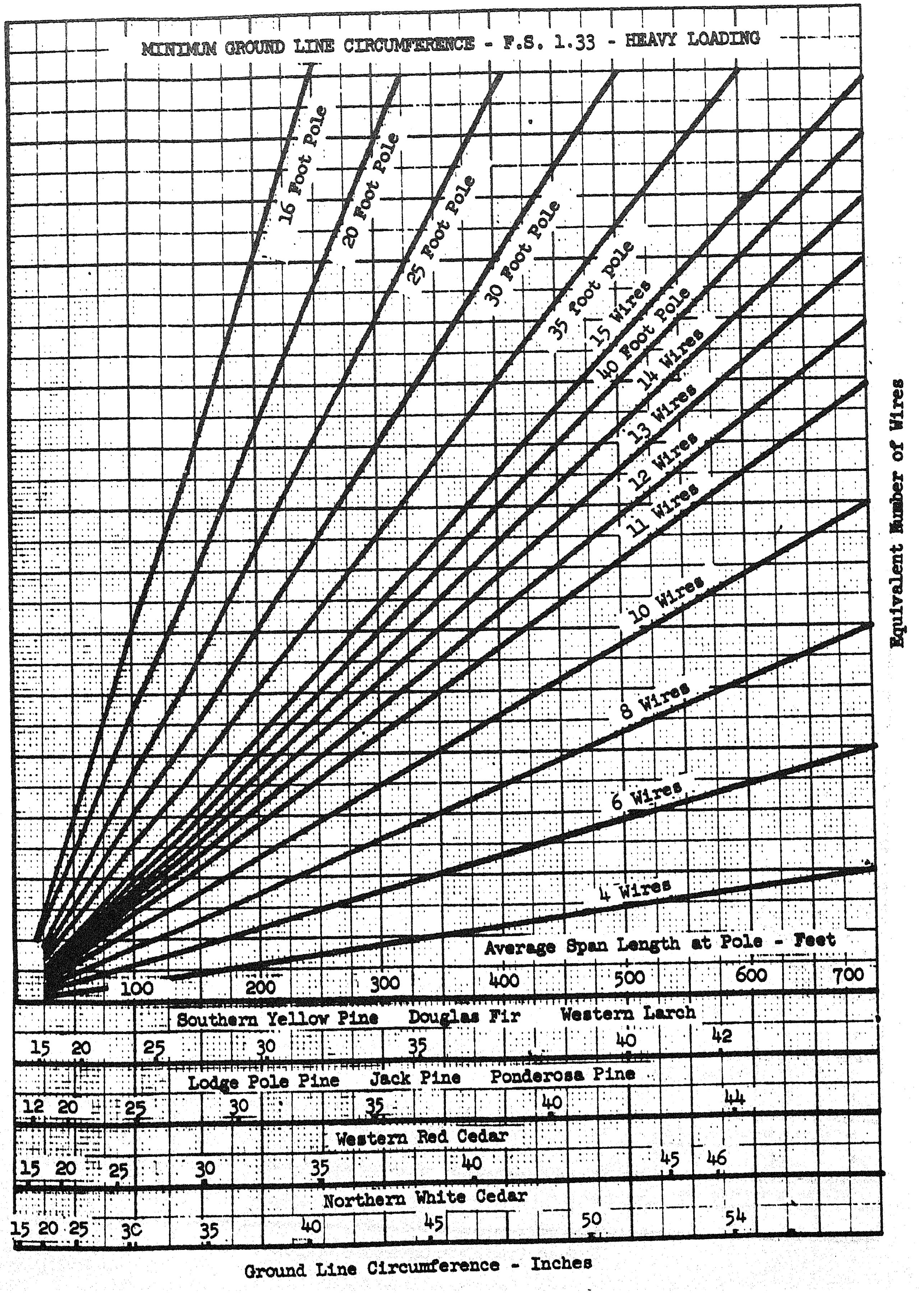
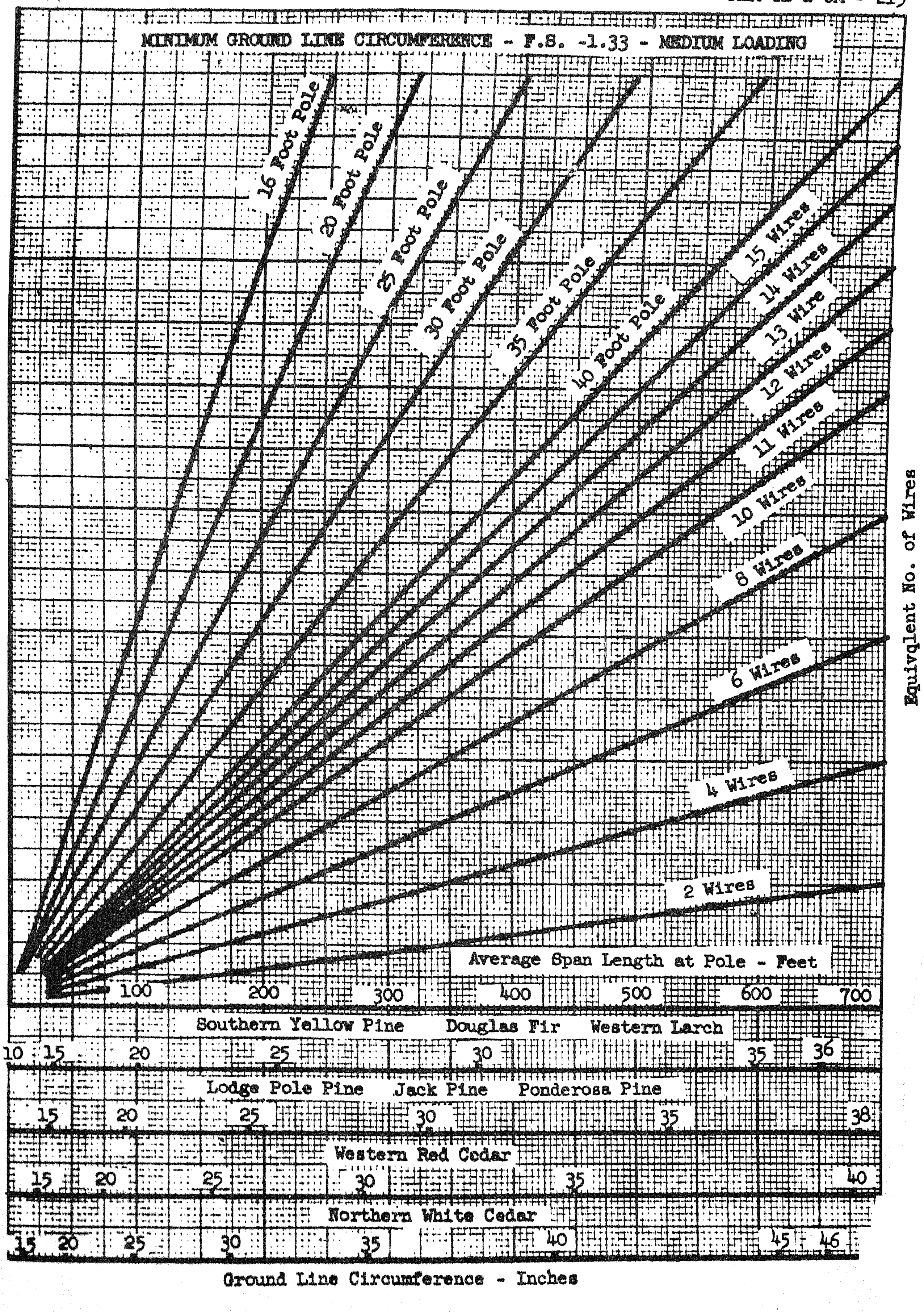

MINIMUM GROUND LINE CIRCUMFERENCE - F.S. 1.0 - LIGHT LOADING
16 Foot Pole
20 Foot Pole
25 Foot Pole
30 Foot Pole
35 Foot Pole
40 Foot Pole
10 Wires
8 Wires
6 Wires
4 Wires
2 Wires
Equivalent No. of Wires
Average Span Length at Pole - Feet
100
200
300
400
500
600
700
Southern Yellow Pine Douglas Fir Western Larch
12
15
20
22
Lodge Pole Pine Jack Pine Red Pine Ponderosa Pine
12
15
20
23
Western Red Cedar
13
15
20
24
Ground Line Circumference - Inches

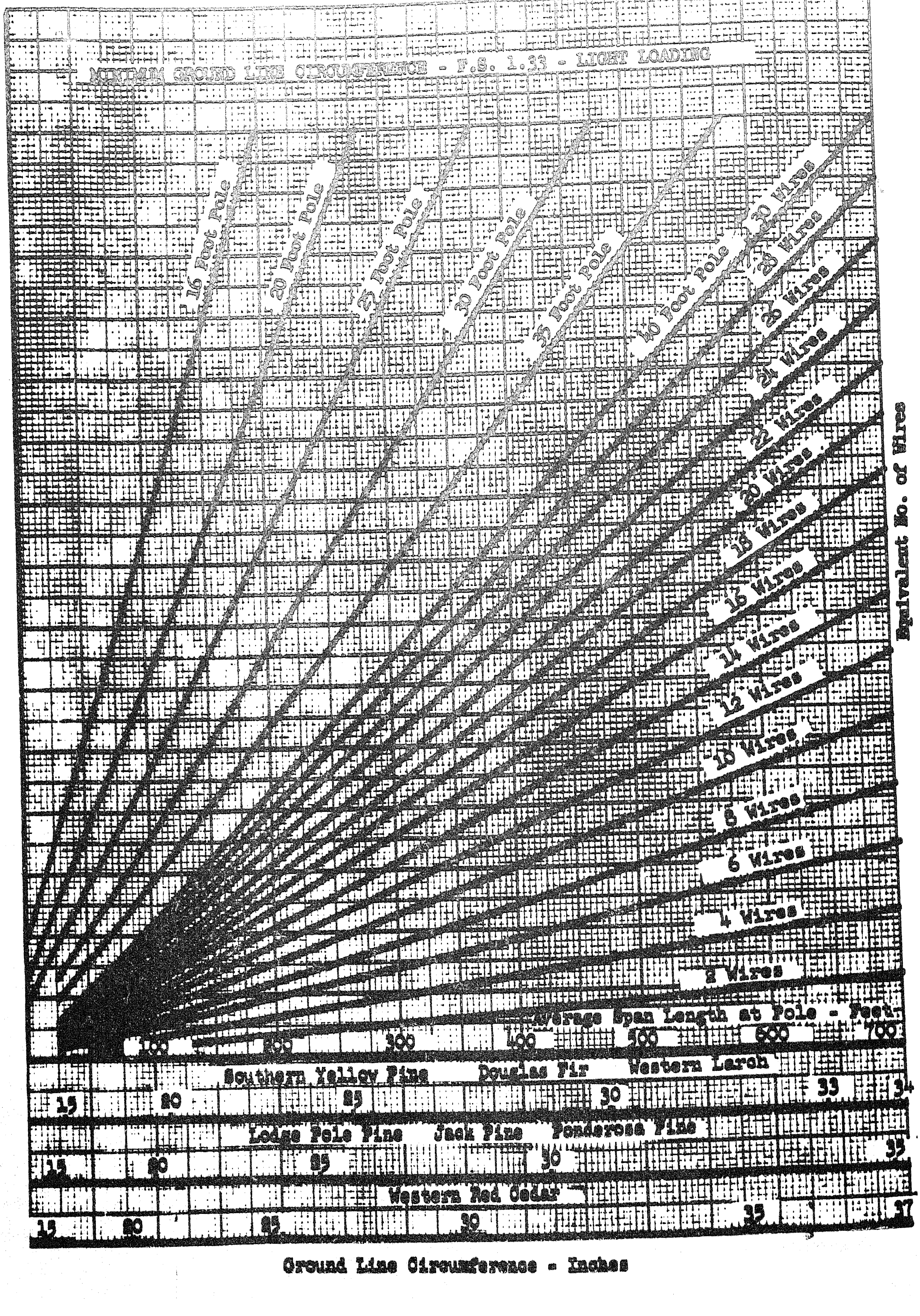
CHART 4


MINIMUM GROUND LINE CIRCUMFERENCE - F.S. 1.33 - HEAVY LOADING
16 Foot Pole
20 Foot Pole
25 Foot Pole
30 Foot Pole
35 foot pole
15 Wires
40 Foot Pole
14 Wires
13 Wires
12 Wires
11 Wires
10 Wires
8 Wires
6 Wires
4 Wires
Equivalent Number of Wires
Average Span Length at Pole - Feet
100
200
300
400
500
600
700
Southern Yellow Pine Douglas Fir Western Larch
15 20 25 30 35 40 42
Lodge Pole Pine Jack Pine Ponderosa Pine
12 20 25 30 35 40 44
Western Red Cedar
15 20 25 30 35 40 45 46
Northern White Cedar
15 20 25 30 35 40 45 50 54
Ground Line Circumference - Inches



Ground Line Circumference - Inches

CHART 6



Ground Line Circumference - Inches